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THE MEMBRACID GENUS MULTAREIS, AND A NEW GENUS, MULTAREOIDES (Homoptera)*

Paul P. Cook, Jr.
University of California, Berkeley

(CONTINUED FROM JULY ISSUE)

Multareoides bifurcatus n. sp.
Figs. 31 to 34; 51 to 54

Resembling *Multareoides digitatus,* but anterior pronotal gibbosity higher, nearly coming to a point at bifurcate summit. Length: Female 3.3 to 4.2 mm.; male 3.3 to 3.5 mm.

Pronotum slightly cephalad of humeri high, bifurcate at summit, the distance between the highest points one-third to one-half mm.; posterior pronotal protuberance large, occupying all except apex of caudal half of posterior process (measuring from humeri); usually a slightly inflated area just cephalad of posterior protuberance, sometimes absent, sometimes continuous with the posterior protuberance so that the latter is indefinite, occasionally causing sinuation of dorsal median carina; tegminal venation reticulate; in lateral view, distance between apex of humerus and summit of pronotum approximately 1 mm. in male, 1.25 mm. in female; tubercle on cephalic margin of head mesad of each eye faint or indistinguishable.

Color: Dark areas on cephalic portions of pronotum and on head often present; dark ventrally; femora dark, but often no darker than tibiae.

Male Genitalia: In ventral view subgenital plate broadest one-fourth distance from base, narrowing to one-third distance from apex, distal third usually ovate; in lateral view subgenital plate somewhat boat-shaped, middle half of ventral surface flat, basal fourth turned sharply cephalodorsad, distal fourth evenly rounded toward dorsad; gonoforceps extending cephalad of base of subgenital plate, widest at middle, narrowing to near apex where they become widened and somewhat avicephaliform; in ventral view posterior arm of aedeagus narrowest at base, gradually widening to near bluntly rounded apex; approximately 9 to 11 serrations on distal three-fourths of arm located dorsolaterally; in lateral view length of arm four to seven times medial width, narrowing from near middle to acute apex; tooth of lateral valve shorter than basal width, rounded, relatively larger than in the species of *Multareis* or *Centrodontus.*

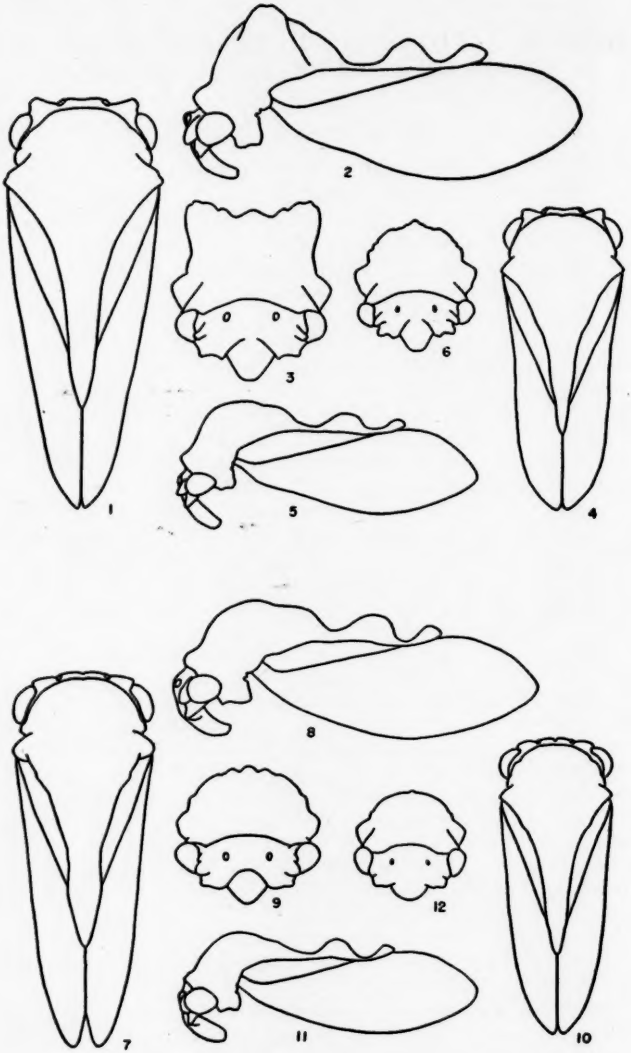
Host: Larrea tridentata Cav.

Distribution: Arid regions of the southwestern United States, northern Mexico, and Baja California.

Holotype ♀, allotype ♂: Tucson, Arizona, July 14, 1950 (Paul P. Cook).

Paratypes: 12 ♀ ♀ and 5 ♂ ♂, Tucson, Arizona, July 14, 1950 (Paul P. Cook); 1 ♂, Tucson, Arizona, May 20, 1934 (R. A. Flock); 3 ♀ ♀, Tuc-

*Contribution No. 814 from the Department of Entomology, University of Kansas.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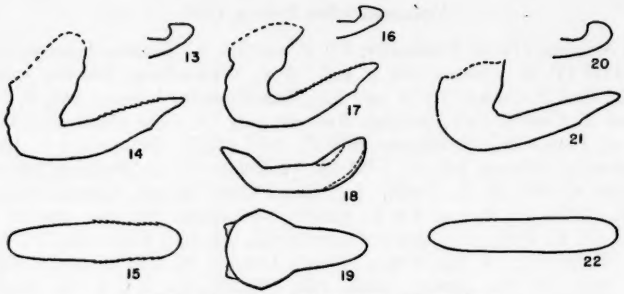
son, Arizona, (H. G. Hubbard); 3 ♀ ♀ and 9 ♂ ♂, Tucson, Arizona, June 16, 1933 (P. W. Oman); 7 ♀ ♀ and 5 ♂ ♂, Wickenburg, Arizona, July 5, 1950 (Paul P. Cook); 4 ♀ ♀ and 1 ♂, Casa Grande, Arizona, July 6, 1950 (Paul P. Cook); 1 ♂, Douglas, Arizona, July 19, 1950 (Paul P. Cook); 2 ♂ ♂, Pima County, Arizona, July 22, 1927 (R. H. Beamer); 1 ♂, Black Mountain, Arizona, July 13, 1932 (R. H. Beamer); 1 ♂, Safford, Arizona, August 6, 1941 (E. L. Todd); 1 ♀, Santa Cruz Village, Arizona, August 10-12, 1916; 4 ♀ ♀ and 4 ♂ ♂, Empire Mountains, Arizona, August 18, 1935 (E. D. Ball); 1 ♀ and 1 ♂, Littlefield, Arizona, September 15, 1931 (E. W. Davis); 1 ♀, Las Vegas, Nevada, October 18, 1929 (David E. Fox); 1 ♀ and 1 ♂, St. George, Utah, July (Wickham); 2 ♀ ♀, St. George, Utah, October 15, 1929 (David E. Fox); 1 ♂, St. George, Utah, September 8, 1930 (E. W. Davis); 1 ♀, Santa Clara, Utah, October 15, 1929 (David E. Fox); 1 ♀, Hot Springs, New Mexico, July 22, 1950 (Paul P. Cook); 1 ♀ and 2 ♂ ♂, Yucca Grove, California, August 7, 1936 (D. R. Lindsay); 14 ♀ ♀ and 1 ♂, Palmdale, California, October 28, 1934 (A. T. McClay); 2 ♀ ♀, Potholes, California, April 7, 1923 (E. P. Van Duzee); 1 ♂, Inyo Kern, California (R. C. Dickson); 1 ♀ and 1 ♂, Little Rock, California, September 13, 1950 (P. H. Timberlake); 1 ♀, El Centro, California, March 18, 1948 (R. A. Flock); 6 ♀ ♀ and 2 ♂ ♂, Mojave, California, August 11, 1949 (R. E. Beer); 1 ♂, Palm Springs, California, May 18, 1917 (E. P. Van Duzee); 6 ♀ ♀ and 3 ♂ ♂, Holtville, California, June 1, 1935 (P. W. Oman).

Holotype, allotype, 18 ♀ ♀ and 14 ♂ ♂ paratypes in the Snow Entomological Collection; 5 ♀ ♀ and 2 ♂ ♂ paratypes in the collection of R. E. Beer, Lawrence, Kansas; 2 ♀ ♀ and 1 ♂ paratypes in the collection of R. A. Flock, Riverside, California; 1 ♀ paratype in the American Museum of Natural History; 2 ♀ ♀ paratypes in the University of Minnesota collection; 10 ♀ ♀ and 3 ♂ ♂ paratypes in the California Academy of Sciences; 13 ♀ ♀ and 10 ♂ ♂ paratypes in the United States National Museum; 20 ♀ ♀ and 15 ♂ ♂ paratypes in the author's collection.

Localities not included in the list of types: California: Coachella, Inyo Mountains, Kern County, Little Lake, San Bernardino County ,Victorville; Arizona: Benson, Congress Junction, Dome, Miami, Phoenix; Nevada: Overton; New Mexico: Carlsbad, Rodeo; Mexico: Gonzales Bay, Baja California.

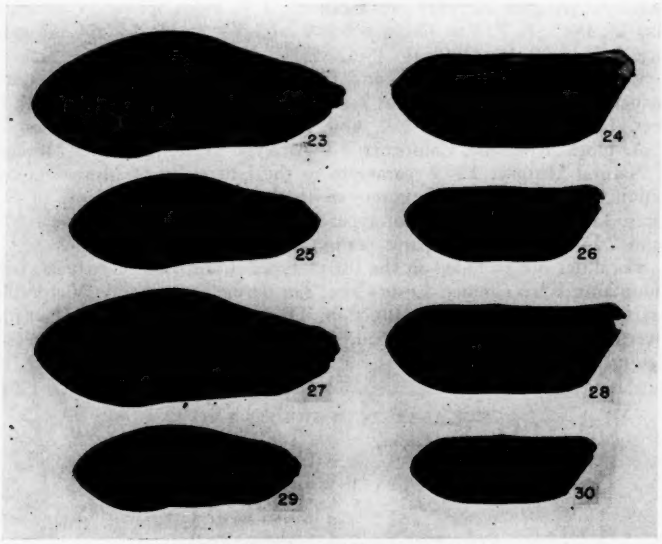
EXPLANATION OF FIGURES 1 TO 12

1.	*Multareis cornutus cornutus* Goding	♀ Dorsal view.
2.	" " "	♀ Lateral view.
3.	" " "	♀ Cephalic view.
4.	" " "	♂ Dorsal view.
5.	" " "	♂ Lateral view.
6.	" " "	♂ Cephalic view.
7.	*Multareis cornutus lawsoni n.* subsp.	♀ Dorsal view.
8.	" " "	♀ Lateral view.
9.	" " "	♀ Cephalic view.
10.	" " "	♂ Dorsal view.
11.	" " "	♂ Lateral view.
12.	" " "	♂ Cephalic view.



EXPLANATION OF FIGURES 13 TO 22

13. *Multareis cornutus lawsoni* n. subsp. ♂ Apex of gonoforceps.
14. " " " ♂ Lateral view of aedeagus.
15. " " " ♂ Ventral view of aedeagus.
16. " " " ♂ Apex of gonoforceps.
17. " " " ♂ Lateral view of aedeagus.
18. " " " ♂ Lateral view of subgenital plate.
19. " " " ♂ Ventral view of subgenital plate.
20. *Multareis cornutus cornutus* Goding ♂ Apex of gonoforceps.
21. " " " ♂ Lateral view of aedeagus.
22. " " " ♂ Ventral view of aedeagus.



EXPLANATION OF FIGURES 23 TO 30

23. *Multareis cornutus cornutus* Goding ♀ Left forewing.
24. " " " ♀ Left hindwing.
25. " " " ♂ Left forewing.
26. " " " ♂ Left hindwing.
27. *Multareis cornutus lawsoni* n. subsp. ♀ Left forewing.
28. " " " ♀ Left hindwing.
29. " " " ♂ Left forewing.
30. " " " ♂ Left hindwing.

One female specimen of this species was included in Van Duzee's (1923) original series of *Multareis digitatus,* and at least some of the specimens which he recorded from Palm Springs, California, and St. George, Utah, are also of this species.

There is a marked variation in size in both sexes. The author has attempted to separate the smaller from the larger specimens without success, due to a more or less continuous gradation. The two are apparently morphologically identical.

Multareoides digitatus (Van Duzee)

Figs. 35 to 38; 43 to 50; 55 to 58

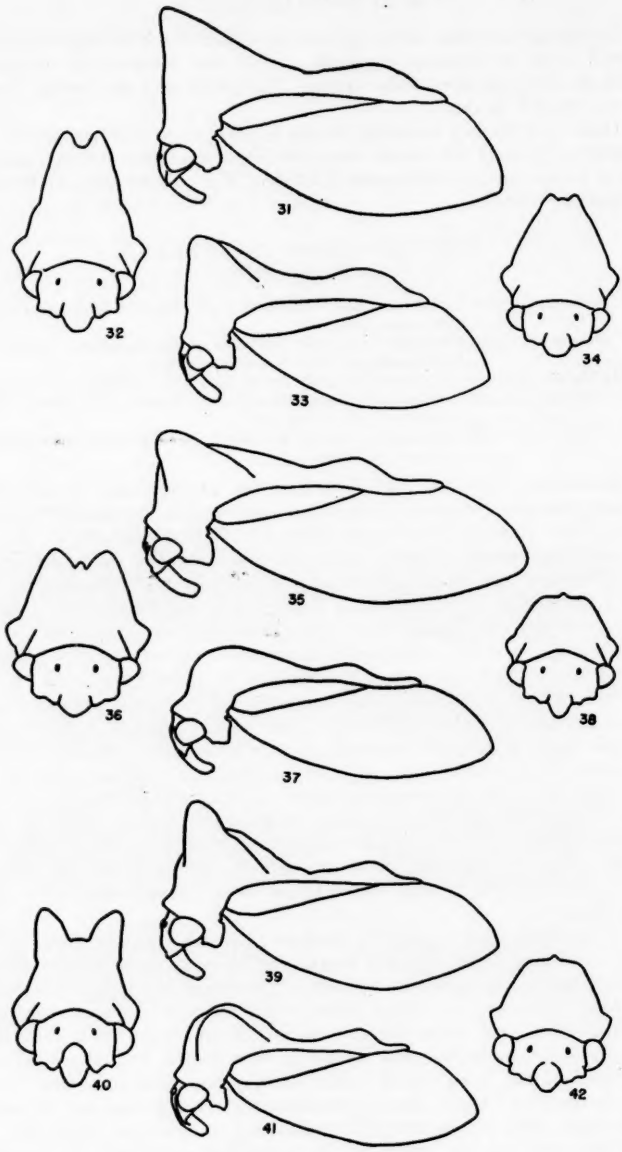
1923 *Multareis digitatus* Van Duzee, Proc. California Acad. Sci., (4) 12:171. (♂ holotype only.)
1927 *Multareis digitatus,* Funkhouser, General Catalogue of the Hemiptera, Fascicle 1, Membracidae, p. 56. (♂ holotype only.)
1943 *Multareis planifrons,* Funkhourser, Bull. Brook. Ent. Soc., 37:166. (Holotype.)
1951 *Multareis digitatus,* Funkhouser, Genera Insectorum, Fascicle 208, Family Membracidae, p. 58. (Holotype.)
1951 *Multareis cornutus,* Funkhouser, Genera Insectorum, Fascicle 208, Family Membracidae, pl. 1, fig. 11.

Resembling *bifurcatus* but pronotum not so high, and usually with cornute processes the apices of which are more widely separated when present. Length: Female 3.3 to 4 mm.; male 3.3 to 3.6 mm.

Anterior pronotal gibbosity above humeri in male bearing rudimentary dorsal cornute or tuberous processes, processes absent, or small processes which are higher by approximately 0.1 mm. than the dorsal median carina at a point directly between them, the distance between their summits approximately 0.4 mm.; female with larger more cornute processes, higher by approximately 0.2 mm. than the dorsal median carina at a point directly between them, their summits approximately 0.5 mm. apart; posterior pronotal protuberance smaller than in *bifurcatus,* occupying approximately middle third of posterior pronotal process; an inflated area or secondary protuberance on caudal slope of anterior gibbosity; tegminal venation less reticulate than in *bifurcatus;* in lateral view, distance between apex of humerus and summit of pronotum or its processes 0.5 to 0.7 mm. in male, approximately 0.9 mm. in female; cephalic edge of pronotum at angle with metopidium, angle and length of edge greater than in *bifurcatus;* tubercle on cephalic margin of head mesad of eye more defined than in the other two species.

Color: Dark areas on cephalic portions of pronotum and on head darker than in *bifurcatus* (if present), thorax and abdomen near black ventrally; femora near black, darker than tibiae; tibiae darker than general coloration.

Male Genitalia: In ventral view subgenital plate broadest one-fourth distance from base, narrowing to one-third distance from apex, distal third usually ovate; in lateral view somewhat boat-shaped, ventral surface with middle half flat, basal fourth turned sharply cephalodorsad, distal fourth evenly rounded toward dorsad; gonoforceps extending cephalad of base of subgenital plate, widest at middle, narrowing to near apex where they are abruptly widened, the apical portion somewhat avicephaliform; posterior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arm of aedeagus in ventral view narrowest at base, gradually widening to bluntly rounded apex; approximately 7 serrations on distal three-fourths of shaft dorsolaterally; in lateral view, length of arm four to eight times medial width, narrowing from near middle to acute apex; tooth of lateral valve shorter than basal width, rounded, relatively larger than in the species of *Centrodontus* and *Multareis*.

Host: Larrea tridentata Cav.

Distribution: Arid regions of the southwestern United States, northern Mexico, and Baja California. Peripheral localities: Hot Springs, and Roswell, New Mexico; Barstow, Sheffield, and Laredo, Texas; Saltillo, Coahuila, Mexico; 53 miles south of Marathon, Davis Mountains, and El Paso, Texas; Tucson, Empire Mountains, and Willcox, Arizona. Also Concepcion Bay, Baja California.

Holotype ♂: Guadalupe Point, Concepcion Bay, Gulf of California, June 17, 1921 (E. P. Van Duzee).

Neoallotype ♀: Hot Springs, New Mexico, July 22, 1950 (Paul P. Cook).

Parallotypes, all ♀ ♀: 23, Hot Springs, New Mexico, July 22, 1950 (Paul P. Cook); 3, Las Cruces, New Mexico, July 1, 1932 (R. H. Beamer); 1, El Paso, Texas, April 27, 1927 (J. O. Martin); 5, Davis Mts., Texas, April 26, 1924 (J. O. Martin); 1, Chiricahua Mts., Arizona, August 7, 1941 (L. H. Banker); 1, Sabino Canyon, Arizona, July 31, 1941 (L. H. Banker); 3, Benson, Arizona, September 3, 1907 (Koebele); 1, Benson, Arizona, June 8, 1936 (E. D. Ball); 1, Willcox, Arizona (E. D. Ball); 5, Empire Mts., Arizona, August 8, 1935 (E. D. Ball); 4, Geronimo, Arizona, April 28, 1924 (J. O. Martin); 1, Tucson, Arizona, (H. G. Hubbard); 1, Tucson, Arizona, July 8, 1939 (Owen Bryant); 4, Douglas, Arizona, July 19, 1950 (Paul P. Cook).

Holotype and 9 parallotypes in the California Academy of Sciences; neoallotype and 23 parallotypes in the Snow Entomological Collection; 4 parallotypes in the United States National Museum; 1 parallotype in the collection of R. A. Flock, Riverside, California; 17 parallotypes in the author's collection.

The females which Van Duzee originally placed with the holotype of this species belong to *Multareoides planifrons*. The cornute or digitate

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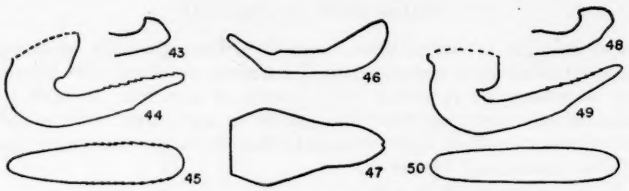
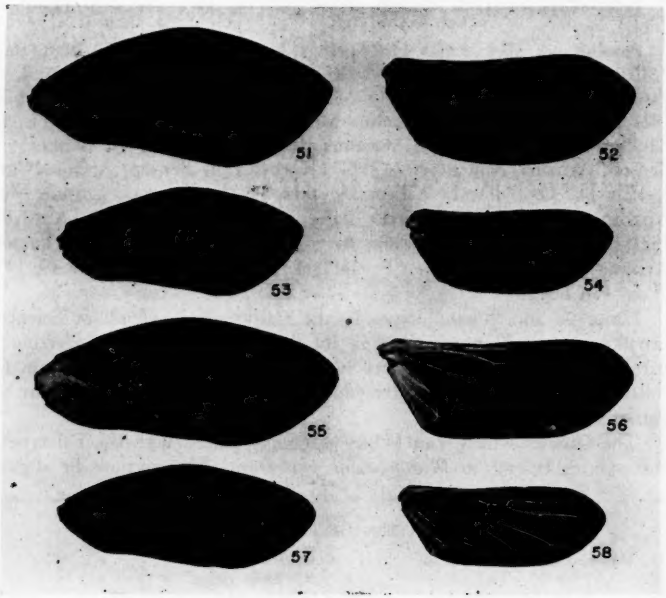
EXPLANATION OF FIGURES 31 TO 42

31. *Multareoides bifurcatus* n. sp. ♀ Lateral view.
32. " " ♀ Cephalic view.
33. " " ♂ Lateral view.
34. " " ♂ Cephalic view.
35. *Multareoides digitatus* Van Duzee ♀ Lateral view.
36. " " ♀ Cephalic view.
37. " " ♂ Lateral view.
38. " " ♂ Cephalic view.
39. *Multareoides planifrons* Van Duzee ♀ Lateral view.
40. " " ♀ Cephalic view.
41. " " ♂ Lateral view.
42. " " ♂ Cephalic view.



EXPLANATION OF FIGURES 43 TO 50

43. *Multareoides digitatus* Van Duzee ♂ Apex of gonoforceps.
44. " " ♂ Lateral view of aedeagus.
45. " " ♂ Ventral view of aedeagus.
46. " " ♂ Lateral view of subgenital plate.
47. " " ♂ Ventral view of subgenital plate.
48. " " ♂ Apex of gonoforceps.
49. " " ♂ Lateral view of aedeagus.
50. " " ♂ Ventral view of aedeagus.



EXPLANATION OF FIGURES 51 TO 58

51. *Multareoides bifurcatus* n. sp. ♀ Right forewing.
52. " " ♀ Right hindwing.
53. " " ♂ Right forewing.
54. " " ♂ Right hindwing.
55. *Multareoides digitatus* Van Duzee ♀ Right forewing.
56. " " ♀ Right hindwing.
57. " " ♂ Right forewing.
58. " " ♂ Right hindwing.

pronotal processes of these females probably suggested the name *digitatus* to him, and indeed *digitatus* would seem more applicable to them than *planifrons*.

Multareoides planifrons (Van Duzee)

Figs. 39 to 42

1923 *Multareis planifrons* Van Duzee, Proc. Calif. Acad. Sci., (4) 12:170. (♂ holotype and ♂ paratype.)

1923 *Multareis digitatus* Van Duzee, Proc. Calif. Acad. Sci., (4) 12:171. (♀ allotype and some other females.)

1927 *Multareis digitatus*, Funkhouser, General Catalogue of the Hemiptera, Fascicle 1, Membracidae, p. 56. (Females.)

1927 *Multareis planifrons*, Funkhouser, General Catalogue of the Hemiptera, Fascicle 1, Membracidae, p. 56. (Males.)

1951 *Multareis digitatus*, Funkhouser, Genera Insectorum, Fascicle 208, Family Membracidae, p. 58. (Females.)

1951 *Multareis planifrons*, Funkhouser, Genera Insectorum, Fascicle 208, Family Membracidae, p. 58. (Males.)

Resembling *digitatus*, but anterior pronotal gibbosity relatively higher and more erect in male, dorsal processes larger and more widely separated in female. Length: Female 3.7 to 4 mm.; male 3.3 mm.

Anterior dorsal gibbosity of pronotum just cephalad of humeri higher and more erect than in *digitatus;* male with rudimentary dorsal processes; in female dorsal cornute processes higher and more widely separated than in *digitatus*, the distance between their summits 0.67 to 0.83 mm., and higher than median carina at a point directly between them by one-sixth to one-third mm.; inflated area on caudal slope of anterior gibbosity similar to *digitatus;* tegminal venation more reticulate than in *bifurcatus;* in lateral view distance between apex of humerus and summit of pronotum or its processes two-thirds mm. in male, 1 mm. (or slightly less) in female; cephalic edge of pronotum at angle with metapidium, angle and length of edge slightly less than in *digitatus;* tubercle on cephalic margin of head mesad of eye less defined than in *digitatus*, more defined than in *bifurcatus;* more deeply punctate than other two species.

Color: Female light brown, darker on pronotum laterally at position of dorsal cornute processes and ventrally; tibiae and femora of about same color; male of nearly uniform brown color.

Male Genitalia: No dissections were made because of lack of sufficient material.

Host: Larrea tridentata Cav.

Distribution: Concepcion Bay and San Marcos Island, Gulf of California, Mexico.

Holotype ♂ : Coyote Bay, Concepcion Bay, Gulf of California, June 18, 1921 (E. P. Van Duzee).

Neoallotype ♀ : Coyote Bay, Concepcion Bay, Gulf of California, June 18, 1921 (E. P. Van Duzee).

Paratype ♂ : Guadalupe Point, Concepcion Bay, Gulf of California, June 18, 1921 (E. P. Van Duzee).

Parallotypes all ♀ ♀ : 4, Guadalupe Point, Concepcion Bay, Gulf of California, June 17, 1921 (E. P. Van Duzee); 1, Coyote Bay, Concepcion

Bay, Gulf of California, June 18, 1921 (E. P. Van Duzee); 1, San Marcos Island, Gulf of California, June 19, 1921 (E. P. Van Duzee).

Holotype, neoallotype, paratype, and 4 parallotypes in the museum of the California Academy of Sciences; 1 parallotype in the Funkhouser Collection of Membracidae; 1 parallotype in the author's collection.

The female of this species is described from the allotype and other females of the original series of *Multareis digitatus* Van Duzee. The females which Van Duzee originally placed in this species belong to *Centrodontus atlas;* their position in that species has been discussed previously (Cook, 1952; pp. 97 and 102).

Acknowledgements

The author wishes to extend deep thanks to Dr. Paul B. Lawson and Dr. C. D. Michener of the University of Kansas for their help in the preparation of this paper, to Hugh B. Leech of the California Academy of Sciences and Miss Louise M. Russell of the United States Department of Agriculture for comparing specimens with types and for lending valuable material, and to the following for lending specimens: Dr. R. A. Flock of Riverside, California; Dr. E. S. Ross of the California Academy of Sciences; Dr. Roland Fischer and Dr. E. F. Cook of the University of Minnesota; Dr. Mont A. Cazier of the American Museum of Natural History; and Dr. George F. Knowlton of Utah State Agricultural College.

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Van Duzee, Edward Payson, 1923. Expedition of the California Academy of Sciences to the Gulf of California in 1921. Proceedings of the California Academy of Sciences, series 4, vol. 12, pp. 249-318.

NEW MEXICAN TACHINIDAE (DIPTERA)[1]

H. J. REINHARD
College Station, Texas

The new genera and species described below are based upon material from Mexico collected mainly by Dr. W. G. Downs, to whom I am indebted for the privilege of studying the same. Types of the new forms are in my collection.

Genus *Paradidyma* Brauer and Bergenstamm

Paradidyma Brauer and Bergenstamm, Zweifl. d. Kais. Mus., 5, 1891, 382, (type, *Didyma validinervis* Wulp).-Coquillett, Rev. Tach., 1897, 126. - Reinhard, Proc. U. S. N. M., 83, 1934, 17.

Paradidyma merista, n. sp.

Female differs from *singularis* Townsend principally as follows: Outer verticals differentiated and about half as large as inner pair; mesonotal vittae much less distinctly defined; petiole of first posterior cell more elongated or nearly twice as long as small cross vein.

Vertex 0.28 of head width; ocellars well developed; two proclinate orbitals; frontalia at middle nearly as wide as parafrontal, latter gray pollinose, darker along inner margin; one frontal beneath antennal base; antenna black, narrow base of third segment and apex of second tinged with red; arista thickened on basal third or less, micro pubescent; clypeus silvery parafacial less so, bare outside of main row of bristles; cheek two-fifths eye height; palpus reddish yellow, slender; proboscis short. Thorax black, gray pollinose, notal vittae in rear view distinctly separated into four narrow black stripes which become obsolete well before base of scutellum; acrostichal 2, 1 (hindmost small and in a transeverse line with posterior dorsocentrals); dorsocentral 3, 3; presutural 1 (outer); intraalar 2; supraalar 3 (anterior one small); sternopleural 3; pteropleural small; scutellum with 2 lateral, 1 decussate apical and 1 discal pair; prosternum and postnotal slope setose; propleuron bare. Legs black; fore tarsus elongate, compressed and swollen, claws and pulvilli atrophied. Wing subhyaline; veins yellowish, third setulose nearly to small cross vein; first posterior cell closed petiole reaching costa well before wing tip; last section of fifth vein one-third length of preceding; costal spine strong; epaulet black; calypter smallish, white tinged with yellow on outer margin. Abdomen shining black, narrow basal margin of intermediate segments and basal half of fourth silvery pollinose; latter with a row of discals; first segment without median marginals, second with one pair and third with a complete marginal row; genitalia retracted.

Length, 6-6.5 mm. Male unknown.

Holotype: Amanalco, Mexico, May 5, 1950 (W. G. Downs). Paratype: 1 female, same data as type.

Genus *Epidexia* Townsend

Epidexia Townsend, Jr. N. Y. Ent. Soc., 20, 1912, 112 (type, *E. pulverea* Coquillett, as *filamentosa* new species); Ins. Insc. Mens., 4, 1916, 54; Manual of Myiology, Part 9, 1939, 185.—Aldrich, Bul. Brk. Ent., Soc., 22, 1927, 20.

[1] Contribution No. 1674, from the Department of Entomology, Texas Agricultural Experiment Station.

Epidexia mimela, n. sp.

Differs from the genotype mainly as follows; antennae and legs entirely black; three sternopleural bristles; discals on abdominal segments two and three as large as median marginals; first posterior cell open at costa, etc.

Male.—Vertex 0.26 of head width; ocellars strong; two to three frontals beneath antennal base; frontalia deep brown, striate, subequal to parafrontal width; antennae as long as face, third segment slightly over three times length of second; arista black, pubescent, thickened on proximal fourth, basal segments short; parafrontal gray pollinose, sparsely black-haired; vibrissae on oral margin; facialia bristled well above middle; parafacial subsilvery, bare, narrowed below; cheek one-fifth eye height; proboscis short, stout; palpus reddish yellow, somewhat flattened and widened apically; occiput gray pollinose, clothed with pale hairs.

Thorax black, gray pollinose, with four black dorsal vittae; chaetotaxy as in *E. pulverea* except three sternopleurals as mentioned; propleuron and postnotal slope bare; posternum bristled and setose on lateral margin. Legs black; middle tibia with two stout anterodorsal bristles; claws and pulvilli moderately elongate. Wing slightly infuscated; veins brownish; costal spine strong; first posterior cell open far before wing tip; calypter opaque white.

Abdomen wholly gray pollinose, black with apex reddish in ground color; first segment bearing one pair of median marginals, fourth strongly bristled on apical half above; genital segments small, reddish yellow; forceps triangular in rear view, narrowly divided beyond middle, tips blunt or broadly rounded; accessory process about as wide as forceps in profile but considerably shorter than same; fifth sternite deeply excised, brownish lobes sparsely black-haired on inner apical margin.

Length, 8.5-12 mm. Female unknown.

Holotype: College Station, Texas, June 16, 1947 (H. J. Reinhard). Paratypes: 2 males, same locality as type, August 6 and 18, 1943 (H. J. Reinhard); and 7 males, Acatlipa, Morelos, Mexico, October 4, 1949 and May 11 to July 29, 1950, all collected by Dr. W. G. Downs.

Stolatosoma, n. g.

Differs from *Epidexia* most obviously in having hairy eyes; other important differences are listed below.

Front arcuate in profile, subequal to length of moderately receding face; vibrissal axis two-fifths to two-thirds length of antennal, latter slightly below eye middle; clypeus moderately depressed, narrowed upwards; epistoma short, full clypeal width and hardly bowed forward from plane of same; facialia bristled to middle or slightly above; vibrissae on oral margin, near lower border of head; antenna reaching to lowest fourth of face, first segment short, third slightly exceeding twice length of second; parafacial bare, strongly narrowed below; frontals in a single row with two or three bristles below antennal base; ocellars proclinate; female with two proclinate orbitals; outer verticals vestigial in both sexes; cheek nearly one-fourth eye height; proboscis short, palpus slender, longer than haustellum; eye slightly oblique, not extending to vibrissal level. Thoracic chaetotaxy: humeral 4-5; notopleural 2; presutural 2; acrostichal 3, 3; dorsocentral 3, 3; intraalar 3; supraalar 3; postalar

3; intrapostalar differentiated; sternopleural 2, 1; pteropleural 1 (small); scutellum with 3 lateral, 1 decussate upturned apical and 1 discal pair; propleuron and postnotal slope bare; prosternum setose to weakly bristled. Legs moderately long; hind tibia subciliate on outer posterior side; hind coxa setose on apex behind; male claws and pulvilli elongate; female fore tarsus slightly thickened and flattened, claws and pulvilli minute. Wing ordinary in size and shape; first posterior cell open well before wing tip; hind cross vein nearer cubitulus than small cross vein; last section of fifth vein about one-third length of preceding; first vein bare, third with 2 or 3 hairs near base; costal spine strong. Abdomen tapering to a pointed tip, narrower and longer than thorax; basal segments each with one pair of median marginals and last two with a complete marginal row besides numerous irregularly spaced discals on the last; one pair of discals on segments two and three; sternites covered; female genitalia not adapted for piercing.

Genotype: *Stolatosoma cidaris*, n. sp.

Stolatosoma cidaris, n. sp.

Male.—Vertex 0.23 of head width, front equibroad on upper third thence moderately diverging downward in facial angle; parafrontal, entire face, cheek and posterior orbit silvery pollinose on black background; frontalia dark brown, subequal parafrontal width; antenna wholly black; arista moderately thickened near base and quite slender beyond, short pubescent to near tip, basal segments short; palpus black and rather thickly black-haired on apical half; cheek bristly on lower margin, bare above, groove reddish in ground color.

Thorax black, with moderately heavy gray pollen on notum which shows four broad velvety black vittae, the outer pair extending almost to base of scutellum; latter black in ground color, disc with changeable gray pollen and a sparse vestiture of erect short hairs on basal half.

Legs black; mid tibia with one stout anterodorsal bristle; tarsi slender, claws and pulvilli equal to or exceeding length of last segment.

Wing subhyaline; veins including costa yellow; epaulet black; calypter semitransparent white.

Abdomen black narrow apex red in ground color, last three segments with patternless gray pollen which extends to hind margin of each in a favorable view; hairs more or less bristly and erect along median line; hypopygium small, retracted; forceps short, united base keeled and prominent in profile, free apical portion shining brown, distinctly narrower and longer than accessory process; fifth sternite broadly and deeply excised, inner margin of each lobe notched before apex, latter broadly rounded, bare.

Female.—Front somewhat broader, at vertex 0.28 of head width; second antennal segment one-half length of third; abdomen somewhat broader but pointed apically as in male, venter and anal segment largely reddish in ground color, hairs on upper surface depressed.

Length, 6-8 mm.

Holotype male and allotype female, Acatlipa, Morelos, Mexico, May 11 and June 2, 1950 (W. G. Downs). Paratypes: 3 males, same data except two dated May 18, 1950.

Colurus, n. g.

Traces to *Pterotopeza* Townsend (type, *Blepharipeza tarsalis* Schiner), but the parafacial vestiture is much coarser and includes a well defined row of bristles extending from the lower frontals to the cheek groove; facialia bristled on lower half or more; second abdominal segment without median marginals, etc.

Head about one-fourth wider than high, facial profile moderately receding, nearly as long as frontal, antennal axis near eye middle and distinctly longer than oral; clypeus moderately depressed; epistoma subequal clypeal width and about half as long as wide, not very strongly produced forward, facialia strongly flattened and approximating one-half clypeal width at level of apex of antenna; vibrissae well above oral margin; haustellum very short, stout; labella large; palpus noticeably flattened, clavate and bowed upward beyond middle; main frontal row extending two or three bristles below antennal base; ocellars absent; male without orbitals or outer verticals; antenna three-fourths length of face, third segment rather slender but only one-fourth longer than elongated second; arista bare, basal segments short; eye bare, reaching about to vibrissal level; check one-fourth eye height; occiput slightly bulged on lower margin and flattened above. Thoracic chaetotaxy; acrostichal 3, 3; dorsocentral 3, 4; intraalar 3; supraalar 3; presutural 2; notopleural 2; humeral 4-5; sternopleural 2, 2; pteropleural 2-3 (smaller than sternopleural); intrapostalar well differentiated; scutellum with 1 discal, 3 lateral and 1 weak upturned apical pair; prosternum setose to bristled; propleuron, postnotal and postalar slopes bare. Claws and pulvilli elongate; hind tibia with a row of even and closely set bristles on outer posterior side. Wing extending well beyond tip of abdomen; costal spine small; first posterior cell open well before wing tip; first vein bare, third with 2 or 3 hairs near base; last section of fifth vein about one-fourth length of preceding. Abdomen short ovate, as broad as thorax; fourth segment small, hardly exceeding one-half length of preceding; segments one and two without any bristles, three and four each with a marginal row; sternites scarcely exposed.

Genotype: *Colurus downsi*, n. sp.

Colurus downsi, n. sp.

Male.—Vertex 0.22 of head width, front widening rapidly from middle forward into facial angle; head pollen deep yellow to light brownish on dark background; parafrontal rather thickly clothed with fine black hairs intermixed with coaser ones before middle; frontalia dark brown, gradually narrowed upward and subequal parafrontal width; antenna rather slender, third segment black, basal two contrasting reddish yellow; arista black, moderately thickened on basal two-fifths; parafacial subequal one-half clypeal width, beset with hairs on entire length outside median row of bristles; palpus yellow; cheek thinly pollinose on dark background, clothed with soft black hairs.

Thorax black, thinly gray pollinose, notum in a flat rear view showing four narrow black vittae, interrupted at suture and stopping well before base of scutellum; latter black, lightly dusted with gray pollen, disc beset with a uniform vestiture of erect short black hairs.

Legs black, rather slender but not very long; mid tibia with one stout and one or two smaller anterodorsal bristles; hind coxa setose on posterior apical margin.

Wing gray hyaline, narrow base including calypters infuscate or blackish; subitulus without stump or fold; epaulet black.

Abdomen subshining black, last three segments thinly gray pollinose, a narrow dark median vitta apparent in some views; short anal segment broadly triangular in dorsal view, with a vestiture of erect hairs and bristles over entire surface; hairs on intermediate segments depressed; anal orifice slit-like, genitalia retracted.

Length, 10 mm. Female unknown.

Holotype: Amanalco, Mexico, May 5, 1950, collected by Dr. W. G. Downs, for whom the species is named.

Nicetria, n. g.

Head a little wider than high, arcuate frontal profile about one-fourth longer than subvertical facial, occipital somewhat bulged below, antennal axis at eye middle, one-half head height and longer than vibrissal; eye bare, large, occupying almost entire side of head; cheek sublinear; female front equibroad from vertex to antennal base, face widening but little below middle; clypeus moderately depressed; facialia bare; epistoma hardly narrowed from clypeus, in vertical plane and somewhat variable in length; first antennal segment short, third slender in female and three to four times length of second; arista short-haired about to middle, basal segments small; parafacial bare, narrow to sublinear below; palpus subcyclindric, barely thickened apically, about as long as haustellum, labella large; one or two frontals below antennal base; female with two proclinate orbitals and differentiated outer verticals; ocellars small to vestigial or entirely absent. Thoracic chaetotaxy: acrostichal 1, 1 (anterior pair far before suture and hindmost in transverse line with posterior dorsocentrals); dorsocentral 2, 3; intraalar 3; supraalar 3 (anterior one small or sometimes absent); presutural 1 (outer); notopleural 2; humeral 2; sternopleural 1, 1; pteropleural 1 (small); postalar 2; intrapostalar not differentiated; scutellum with 3 lateral, 1 hairlike decussate apical (sometimes lacking) and 1 barely differentiated discal pair; prosternum and postnotal slope setose; propleuron bare. Legs moderately elongate, rather weakly bristled; female claws and pulvilli shorter than apical tarsal segment. Wing extending far beyond apex of abdomen; first posterior cell open about length of small cross vein before extreme wing tip; last section of fifth vein short; costal spine not developed. Abdomen short, subglobose, segments one to three normal in length, fourth bowed downward and unusually short in dorsal aspect; intermediate segments each with one pair of stout discals; female genitalia ventral, blunt-tipped, telescopic; sternites covered.

Genotype: *Nicetria peponis*, n. sp.

Nicetria peponis, n. sp.

Female.—Front at vertex and at base of antennae 0.20 of head width; parafrontal gray to yellow pollinose; frontalia deep velvety brown slightly narrower to equal parafrontal width; antenna reaching lower fourth of face,

reddish yellow, third segment more or less infuscated on apical half or more, nearly four times longer than second; arista brownish, moderately thickened at extreme base tapering outward and very slender beyond middle; vibrissae slightly to well above oral margin; palpus pale yellow, beset with delicate white hairs on lower basal half and with stubby black bristlets above, occiput wholly pale-haired.

Thorax and scutellum black, gray pollinose, notum marked with four broad black vittae before the suture and five behind; pleura mostly pale-haired.

Legs yellow, apex of femora and entire tibiae brownish, tarsi still darker or blackish; hind tibia not ciliate, middle one with one strong anterodorsal bristle; first segment of all tarsi elongated and equal to or exceeding the combined length of segments two to five.

Wing membrane with a rather uniform yellowish tinge, third vein with 2 to 4 hairs near base; hind cross vein bicurved and about its length from cubitulus; latter rounded to angulate, with or without a short stump; epaulet black; calypter brownish with narrow outer margin paler or white.

Abdomen black, intermediate segments pollinose in a subtessellate pattern, anal segment with much heavier and more uniform pale gray pollen; segments one and two with one pair of median marginals and three with a complete marginal row; anal segment bearing an arcuate row of 6 to 8 stoutish discals and a decidedly weaker marginal row; hairs on entire upper surface fine and depressed.

Length, 7.5-9 mm. Male unknown.

Holotype: Volcano San Martin, Las Tuxtlas, Veracruz, Mexico, May 29, 1951 (L. Navarro). Paratype: 1 female, same data as type.

Nicetria globosa, n. sp.

Female.—Considerably smaller in build than the preceding species from which it differs in the following characters among others: Front at vertex 0.15 and at antennal base 0.21 of head width; frontalia black, equibroad to vertex and wider than parafrontal on entire length; parafrontal silvery becoming darker near vertex; parafacial bare, very narrow below; antenna wholly black; arista practically bare, enlarged and tapering at extreme base thence very slender to tip; face gradually widening downward from upper third; vibrissae only slightly above oral margin; palpus brown; eye descending almost to lower margin of head, leaving cheek scarcely visible in profile; occiput sparsely clothed with only black hairs.

Thorax black with silvery pollen; four sharply defined black vittae before suture and much less distinct behind; scutellum velvety black without a trace of pale pollen above; pleura black-haired; prosternum and postnotal slope bare.

Legs black, rather slender but not very long, weakly bristled; claws and pulvilli small.

Wing reaching well beyond tip of abdomen, membrane with a distinct brownish tinge; first posterior cell narrowly open at wing tip; hind cross vein straight ending nearly midway between small cross vein and cubitulus; latter without stump or fold and near hind margin of wing; costal spine vestigial; epaulet black; calypter semitransparent with a uniform tawny tinge.

Abdomen globular, only the three basal segments visible in dorsal aspect, black with broad basal margin of segments two and three gray pollinose, anal segment bowed downward and retracted, thinly gray pollinose; genitalia ventral, tubular, protractile, blunt-tipped.

Length, 5 mm. Male unknown.

Holotype: Volcano San Martin, Las Tuxtlas, Veracruz, Mexico, May 29, 1951 (L. Navarro).

Genus *Xiphomyia* Townsend

Xiphomyia Townsend, Ins. Insc. Mens., 4, 1916, 125-6 (type, *X. gladiatrix* new species). - Aldrich, Proc. U.S.N.M., 69, 1926, 11-12.

Xiphomyia rivalis n. sp.

Female.—Similar to the genotype but the exerted sharp-tipped piercer is noticeably shorter and the ocellars are well developed.

Front golden pollinose, at vertex 0.27 of head width; frontalia brownish black, two-thirds parafrontal width; facialia weakly bristled on lower fourth and narrower than bare parafacialia; vibrissae large, on oral margin; antenna black, elongate second segment about one-half length of third; arista micro pubescent, evenly tapered near base and very slender beyond middle; cheek one-sixth eye height, grayish pollinose including lower part of parafacial; palpus spatulate, brown basally becoming paler toward tip; proboscis short; occiput flat, rather thickly clothed with pale hairs.

Thorax and scutellum black, gray pollinose with a yellowish tinge on notum; latter marked with four dark vittae before suture and five behind; four post dorsocentral and three sternopleural bristles; scutellum with three lateral, no apical and two pairs of discals; postnotal slope and prosternum setose. Legs black, mid tibia with two anterodorsal bristles; claws and pulvilli shorter than last tarsal segment. Wing hyaline; veins reddish, third with three or four hairs near base; first posterior cell open well before wing tip; costal spine vestigial; epaulet black; calypter with a slight yellowish tinge.

Abdomen narrower than thorax, black, last three segments with gray pollen extending well beyond middle of each in most views; first two segments with one pair of stout erect discals besides a marginal row on segments three and four; piercer bowed in profile extending about to apex of first abdominal segment.

Length, 10 mm. Male unknown.

Holotype: Acatlipa, Morelos, Mexico, July 14, 1950 (W. G. Downs).

In the present species and *X. texana* (Ent. News, 34, 1923, 267) the female piercer does not attain the base of the abdomen, but extends to the hind and middle coxae in *X. auriceps* and *X. gladiatrix*, respectively.

Genus *Lixophaga* Townsend

Lixophaga Townsend, Taxonomy Muscoidean Flies, 1908, 86 (type, *L. parva* new species); Jr. N. Y. Ent. Soc., 21, 1913, 303; Manual of Myiology, Part 4, 1936, 262-263; Ibid., Part 9, 1939, 185-186. - Aldrich, Ins. Insc. Mens., 12, 1924, 146; Proc. Ent. Soc. Wash., 27, 1925; 133. - Curran, Bull. Amer. Mus. Nat. Hist., 61, 1930, 98-99.

Lixophaga scintilla, n. sp.

Readily distinguished from all known species by the jet-black palpi; male without orbital bristles; postnotal slopes setose, etc.

Male.—Vertex 0.26 of head width; parafrontal golden yellow, parafacial concolorous becoming paler below, clypeus, cheek and occiput cinereous; frontalia velvety black, subequal parafrontal width; ocellars strong; outer verticals differentiated but not very long; frontals about eight in a single row, uppermost two stouter and reclinate; parafacial bare, hardly narrowed below; antenna black, rather slender, third segment a little narrower than parafacial; arista black, pubescent, slightly thickened near base; facialia with three or four bristly hairs above vibrissae; latter on oral margin; cheek about one-fifth eye height; proboscis short, stout; occiupt gray pollinose, clothed with pale hairs and bearing a partial row of black setulae along upper margin behind occipital row.

Thorax black, with heavy golden pollen above interrupted by four narrow black vittae; acrostichal 3, 3; dorsocentral 3, 3; presutural 2; intraalar 3; supraalar 3; sternopleural 3; pteropleural small; intrapostalar well developed; scutellum with 3 lateral, 1 depressed discal and 1 small decussate apical pair; prosternum setose. Legs black, moderately long but not very slender; mid tibia with one anterodorsal bristle; claws and pulvilli longer than apical tarsal segment. Wing subhyaline, but with a light brownish tinge except along hind margin; costal spine shorter than small cross vein; first posterior cell open well before wing tip; third vein with three setulae at base; calypters pale yellow.

Abdomen black in ground color, last three segments with dense yellow to golden pollen on basal two-thirds, remainder of each shining black; two basal segments each with one pair of median marginals; third segment with a marginal row of about 12 long, erect bristles; last segment with a discal and a marginal row; hypopygium smallish, retracted; sternites covered.

Length, 8.5 mm. Female unknown.

Holotype: Acatlipa, Morelos, Mexico, July 29, 1950 (W. G. Downs).

Lixophaga remora, n. sp.

Female.—Essentially like the preceding species except as follows: Palpus yellow; parafacial including clypeus and cheek silvery pollinose; outer vertical half as long as inner one; two proclinate orbitals; vertex 0.33 of head width, gradually widening downward into facial angle; apical scutellars absent; claws and pulvilli shorter than last tarsal segment; abdominal bristling weaker; genitalia retracted within tip of abdomen, not adapted for piercing.

Length, 6.5 mm. Male unknown.

Holotype: Acatlipa, Morelos, Mexico, September 1, 1950 (W. G. Downs). Paratype: 1 female, same data, except dated June 30, 1950.

This species was apparently collected in close association with the preceding form and except for the wide difference in color of the palpi might be considered the opposite sex of the same.

THE BIOLOGY AND CONTROL OF THE HACKBERRY PSYLLIDS IN KANSAS[1]

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The study of the psyllid galls of hackberry (*Celtis occidentalis L.*) was intensified by the recognition in 1946 that the psyllids which sometimes collect on house screens in the fall emerged from hackberry galls. This indicated that some incorrect ideas prevailed, especially locally, about the life cycles and overwintering stage of the different species of psyllids responsible for these galls. Furthermore, the adults and the galls are the subjects of some correspondence each year. The galls detract from the appearance and popularity of the hackberry tree. Home owners and nurserymen ask what causes these galls and how they can be prevented. This paper includes the more important observations on the life histories and control of the hackberry psyllids at Manhattan extending over an eight-year period.

The insects of the genus *Pachypsylla* (Psyllidae:Homoptera), commonly known as hackberry psyllids, are all gall makers on the hackberry tree and are restricted in range, as is the hackberry, to the continent of North America. Tuthill's monograph on the family (1943), which contains the most up-to-date review of the genus, listed seven species of *Pachypsylla* in the United States: *P. venusta* (Osten-Sacken), *P. celtidis-mamma* (Fletcher), *P. celtidis-vesicula* Crawford, *P. celtidis-gemma* Riley, *P. celtidis-inteneris* Mally, *P. pallida Patch,* and *P. dubia* Patch. Since Tuthill's work was published, Caldwell (1944) described and named *P. tropicala* on the basis of a single male specimen collected in Tepoztlan, Morelos, Mexico. Walton (1944), in his study of *P. celtidis-gemma,* indicated that the insect called *P. cucurbita* by Packard (1890) and subsequently considered to be identical with *P. celtidis-mamma* by other workers was a distinct species on the basis of its chromosome count.

As is true of many of the gall-making Hymenoptera, each species of *Pachypsylla* makes a specific kind of gall. In fact, some of the older workers described species of the insect on the basis of the gall alone and ignored the morphological characters of the insects themselves, with the result that there is considerable confusion concerning the synonymy and the varietal forms.

The hackberry psyllids whose habits are known may be grouped into two categories: (A) the leaf gall makers which form galls on some part of the leaf blade or petiole, and (B) the woody gall makers which form galls on any part of the tree other than the leaf, these galls being of harder texture than the leaf galls.

Notes on the Habits of the Species of Pachypsylla, with a brief Review of the Literature of each

1. *Pachypsylla venusta*—"the petiole gall psyllid."

The galls made by this insect are polythalamous and located on the leaf

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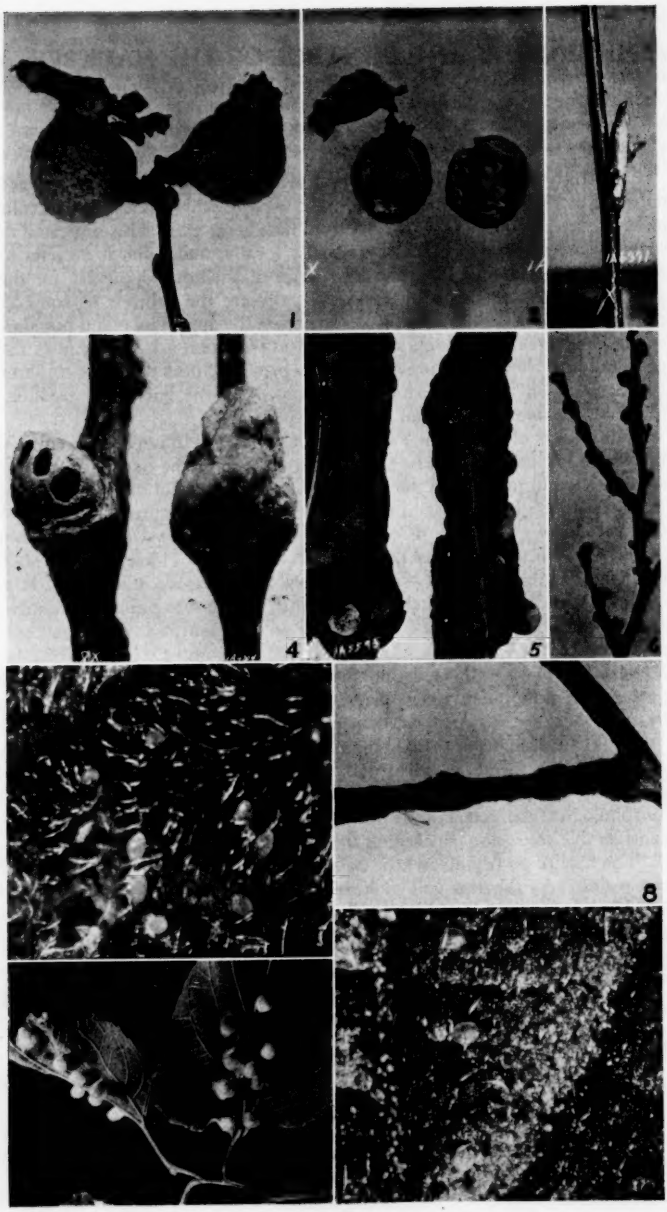
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petiole (Figs. 1 and 2). A difference of opinion has existed as to whether the adults emerged in the fall or in the spring. Tuthill (1943) wrote that they overwintered in the gall and emerged in the spring, but Wells stated that they emerged in the fall and hibernated as adults on the bark.

This species was listed by Tuthill (1943) from Iowa, Kansas, Colorado, Texas, New Mexico, Ohio, Mississippi, Tennessee, North Carolina, New Jersey, Idaho, Utah, New York, and Connecticut.

The grayish or light brownish, globular galls caused by this species do not occur on all hackberry trees in the vicinity of Manhattan. They vary in size but are readily seen in trees. The psyllids winter in the galls which do not drop with leaves but remain on the trees. When inhabited twig galls are brought into a warm room, the adult psyllids usually emerge in a few days. Old empty galls persist on the trees at least into the next year.

An interesting phenomenon was observed by Knowlton (1933) in Utah, where he found adults of the potato psyllid, *Paratriozoa cockerelli* (Sulc.) overwintering in a petiole gall which had been vacated by the *Pachypsylla* adults. He also found a parasite of the genus *Amblymerus* in a *venusta* gall.

The twig gall is not numerous enough even on susceptible trees to do noticeable injury to the tree nor to detract seriously from the appearance of hackberry trees. The adults of this species do not enter homes nor collect on screens in numbers.

2. *Pachypsylla celtidis-vesicula*—"the blister gall psyllid." Original common name.

Tuthill (1943) stated that the adult is similar to *P. c.-mamma* but "distinctly smaller; the wing pattern is often more or less diffuse. . . . The gall formed on the leaves of hackberry is of a quite different type from that of *c.-mamma;* it is blister-like and more prominent on the upper than on the lower surface. Very many galls are found frequently on the same leaf and they are

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Explanation of Plate I.

Photographs 1-6 and 9 were arranged for by the senior author: numbers 7, 8, and 10 by the junior author. All specimens were collected at Manhattan, Kansas.

1. Hackberry petiole gall *(Pachysylla venusta)* from experimental tree, Dec. 1946.
2. Hackberry petiole gall cut open to show the internal structure and the gall cavities within which psyllid nymphs were present. Feb. 15, 1945.
3. Blister gall psyllids on swelling hackberry buds. April 20, 1945.
4. Old bud gall (*P. celtidis-gemma*) at left showing exit holes made by Hymenopterous parasites. At the right is an inhabited, current season's bud gall. Jan. 1945. Det. Muesebeck.
5. Nipple galls and a few blister galls on dropped hackberry leaves. Note leaf curling. Dec. 1946.
6. Hackberry twigs heavily infested with the bud gall psyllid *(P. celtidis-gemma.)* Note swollen buds. April, 1949.
7. Eggs of the blister gall psyllid *(P. celtidis-vesicula)* on the under side of hackberry leaves. May, 1951.
8. Hackberry twig heavily infested with the twig gall *(P. celtidis-inteneris)*. Note the swellings which indicate the locations of these bark galls. May ,1951.
9. Young, growing nipple galls showing the hairy covering typical of the early stages of development. May 27, 1937.
10. Nymphs of the blister gall psyllid *(P. celtidis-vesicula)* on the upper side of a hackberry leaf. May, 1951.

found on the same leaf with *c.-mamma galls*. The species is extremely abundant. It overwinters in the adult stage as does its relative and in company with it sometimes becomes a household nuisance in the fall." This insect follows a life-cycle similar to that of the next species (Figs. 3, 5, 7, and 10). Caldwell (1938) stated that the eggs were laid on the under side of the leaves. They began to hatch in twelve days and the nymphs crawled to the upper side of the leaves to begin feeding. Eight to twelve days later, they were enclosed in a blister-like gall. The nymphal period was approximately 136 days, after which the adults emerged and went almost directly into hibernation.

It was observed by the junior author that within two or three days after the blister gall adults appeared, they copulated and laid eggs on the under sides of the new leaves. During copulation, the adults were disposed side-by-side on a twig or leaf, and faced in the same direction. The male attached itself to the female by extending its flexible abdomen under its wings and curving it around to meet the end of the female's genitalia. The eggs (Fig. 7) were about twice as long as broad, football-shaped, smooth, glistening white, and were laid singly anywhere on the leaf surface. They hatched in eight to twelve days and the nymphs crawled to the upper side of the leaves where they began to feed.

About a week after feeding started, the nymphs had sunk into a slight depression. In another three or four days the surface of the leaf had grown completely over the nymph, which showed no change in size up to the time it was enclosed in the gall. At first, the gall was a barely visible nodule less than half a millimeter wide, and the same color as the rest of the leaf. It was seen more easily on the under side of the leaf than on the upper side even though the nymph had sunk in from the upper side, because the leaf tissue above the nymph had not yet thickened, (Fig. 5). About a month later, the gall was a millimeter and a half wide, convex on both sides of the leaf, and conspicuous because it was yellowish-green to yellow and contrasted with the normal dark green of the rest of the leaf. In the fall, when the leaves were turning yellow prior to falling, the galls turned brown but retained their conspicuous appearance. Tuthill listed the known distribution of this species as Iowa, Kansas, Nebraska, Oklahoma, Arizona, Louisiana, Ohio New York, New Jersey, and Connecticut.

The smaller blister gall adults have been by far the most abundant species on window screens at Manhattan during these studies. It had been believed generally that the larger nipple gall adults predominated.

3. *Pachypsylla celtidis-mamma*—"the hackberry nipple gall psyllid."

Tuthill (1943) stated that the galls formed by this species developed "into a more or less mammiform growth on the underside of the leaf. On the upper surface of the leaf, a depression occurs, cupping down into the gall. The shape of the gall itself is quite variable, often with a nipple-like tip, sometimes conical, glaborous, or pubescent. Usually they are monothalamous."

He stated that "the adults emerge in the fall, overwinter in the crevices of the bark, etc.; early in the spring they fly to the twigs, and after mating, the females begin to deposit eggs about as soon as the leaves begin to appear. The nymphs feed on the lower side of the leaves and are soon encased in the gall.

There is but one generation per year, the nymphs reaching maturity in September. . . "

"The variation in the species is quite marked, especially the coloration, most markedly in the wing pattern, so much so that when first encountered it appears several species must be present." The shape of the galls is variable.

He stated further that "adults from the hackberry nipple gall frequently become a nuisance in the house in autumn when seeking hibernation quarters. Large numbers often collect on the screens, which barrier they readily penetrate and move into the household to hide for the winter. Typically they seek shelter in the rough bark of the hackberry and other trees . . . It undoubtedly occurs throughout the range of its host species, hackberry (*Celtis occidentalis* L.)"

The adults of this species emerge in September and October in Kansas and overwinter in the adult stage in undetermined protected places. The adults mate in the spring, and lay eggs as the leaves appear. The nymphs feed on the lower side of the leaves and create a nipple-shaped gall (Figs. 5 and 10). Mally (1894) described the egg, nymph, and adult, and Stough (1910) made a study of the comparative morphology. He stated that the overwintering adults were difficult to find in March in the creases of the rough sheltering bark on the trunk of the tree since their general color resembles that of the bark. He found them in large numbers on the sticks and pieces of the bark lying on the ground. He never obtained a living adult from a gall on a leaf in the spring. If any failed to leave the galls in the fall, they perished. The adults became active with warmer weather in Iowa the latter part of March. On warm sunshiny days in early April, they were out on the tips of the limbs but they returned to the trunk for the cool night. They were readily dislodged from the limbs by shaking, so a wind could blow them off. The adults collected on the opening buds in April and May and deposited eggs on the leaves. The galls began to form early by the leaf tissue growing around the nymph or in some cases two nymphs. He said the partly grown nymph saws its way out of the gall. Mally stated incorrectly that this species is spread by gall-bearing leaves scattered by the wind or carried by streams perhaps many miles. The species has been recorded by Tuthill (1943) from Iowa, Nebraska, Kansas, Oklahoma, Arizona, Louisiana, Ohio, New York, New Jersey, and Connecticut.

The first point of interest to come out of these studies is that both the nipple and blister gall psyllids emerge in the fall and not in the spring as stated in Insects in Kansas (p. 189). The senior author was following Felt and Rankin (1932 p. 241) who stated incorrectly that "the winter is passed in the galls and adults issue in the spring when the leaves are about one fourth out." Apparently all of the leaf gall-making psyllids winter as adults "in cracks of the bark on hackberry or among the debris on the ground" (Kotinsky) as has been described by writers from Mally (1893) to Tuthill (1943).

The nipple gall psyllids followed much the same life cycle as the blister gall makers. The first psyllids to appear on the trees in the spring were the petiole and nipple gall makers. The time at which they were first seen was closely correlated with the time at which the hackberry tree began to leaf out. Considerable variation was evident in the date at which the first leaf buds opened. In 1951, the first swelling buds were seen on April 16 the last

ones on May 30, on a single branch of a tree which otherwise was in full leaf. In both cases, adult blister gall psyllids were feeding and copulating on the newly opened buds and first leaves (Fig. 3). Most of the trees began to leaf out during the last half of April and first week of May, and it was during that period that the most leaf gall psyllids were seen. Throughout the budding and leafing period, the adults fed and laid eggs almost entirely on the youngest leaves. The adults disappeared as the leaves expanded and became less pubescent. It has not been established whether they died then or migrated to other buds.

The nymphs of this and the preceding species are pale yellowish-green, with red eyes, and a broadly oval, dorso-ventrally flattened body. They move about readily in the gall cavity and crawl actively when they are removed from their galls.

The nymphs of *P. celtidis-mamma* feeding on the lower sides of the leaves, produce nipple-shaped galls (Figs. 5 and 9) which are light green with a whitish bloom. When young, the galls are sparsely pubescent but later they became glabrous. The upper surface is deeply concave. Occasionally the part of the leaf around the base of the gall is yellow.

Eggs laid by these species were first seen on May 20, 1951. They were white and similar in appearance to those of the petiole gall psyllid (Fig. 7). They were deposited singly or in groups of two to six in the angles formed by the branching of the veins on the under sides of the leaves, and were concealed so well by the hair projecting from the veins that they were almost invisible except on very close inspection.

Examinations of thirty-five hackberry trees in 1951 showed marked differences in the distribution of each species of *Pachypsylla*. While the blister gall psyllid was the commonest and most evenly distributed species, this species as well as others varied in numbers on trees. On twenty-four of the trees, the blister gall psyllid was predominant, every leaf bearing three or four to more than one hundred galls. On the other hand, few nipple galls were found on these trees, while on another tree, almost every leaf bore several nipple galls as well as blister galls.

The nymphs of *P. celtidis-vesicula* and *P. celtidis-mamma* emerge from their leaf galls during the last half of October, before the hackberry leaves have fallen, through holes cut by rotating their abdomens, at the end of which are rings of short, stiff spines. The pupal-like final instar nymphs rasps a small hole in the base of the nipple galls on the upper side of the leaves where the gall wall is thinnest and emerges about mid-October. One to three small holes occur indicating the presence of one to three psyllids in the nipple gall. The psyllids are almost colorless after emergence but, in a half hour, normal coloration is attained. The grown nymphs are flat with prominent wing-pads. Psyllid adults seem to prefer north screens and shaded areas. They were not dislodged by opening and closing the screen doors. They were present day and night on the screens for many days extending into November. By December, they dispersed to the extent that they were almost impossible to find. While most authors have stated that the adults overwinter on the bark, no good evidence of this could be found at Manhattan. Examinations of the leaves beneath the trees yielded a few psyllids but not enough to account for

the large numbers seen earlier in the fall. Possible reasons for this may be their dispersal by flight or wind, or a high mortality rate during the winter.

No clear relationship between the yellow discoloration of the foliage on some trees and the galls could be demonstrated. Leaves containing several galls appear to drop before leaves without galls. They also curl on the tree and after dropping to a greater extent than uninfested leaves.

It is believed generally that hackberry psyllids do not affect the vitality of the tree but actually there are no data on this question. The profuse yellow spotting and premature dropping of the leaves, both of which characteristics cause objections to the use of the tree in yards, may be the result of a large number of psyllids feeding on the tree. At any rate, home owners and nurserymen prefer hackberry trees without galls so a satisfactory control might be widely applied.

4. *Pachypsylla celtidis-gemma*—"the bud gall psyllid."

This species has been more thoroughly studied than any other species of this genus (Figs. 4 and 6). Weiss (1921) gave an account of the life-history and Walton (1944) described the instars and studied histologically the effect of the nymphs upon the young buds. The latter author found that little damage was done to the tree by this species since enough buds escaped injury to keep the tree healthy. However, older trees attacked heavily appeared unsightly because of the galls.

The bud gall psyllid is the only species of this genus which has been reported to feed on plants other than hackberry. Slingerland (1895) mentioned an infestation of bud galls made by *P. celtidis-gemma* on mulberry. The eggs were laid in May and June on the twigs. As a control, he suggested pruning the infested twigs in the fall and burning them. Crawford, in his monograph on the Psyllidae (1914), included the following locality and host record in his discussion of this species: "Natchitoches, Louisiana (Cushman and Pierce), on *Crataegus,* March 28, 1907."

The bud gall psyllid was seen for the first time at Manhattan in 1944, so this is believed to be the first published report of its presence in the state. This species of psyllid has been collected in most states from Kansas eastward to the Atlantic Coast.

5. *Pachypsylla celtidis-inteneris*—"twig gall psyllid."

Little has been mentioned about this insect, probably because the galls, which are located under the bark of twigs, usually near the bases of buds (Tuthill, 1943, Caldwell, 1938), are very inconspicuous (Fig. 10). This species has been recorded from Iowa, Illinois, and Ohio. This is believed to be the first report for Kansas.

Wherever galls of *P. celtidis-gemma,* the bud gall psyllid, and *P. celtidis-inteneris,* the twig gall psyllid, occurred they were about equally common. On the thirty-five trees mentioned above, both of these species occurred sparsely, approximately 5 per cent of the buds being infested. On ten other trees, almost all of the buds were infested by *P. celtidis-gemma* and the twigs had a lumpy appearance due to the large number of twig galls, but there were very few blister galls and nipple galls.

This distribution is difficult to explain on the basis of any observations made in the present study. Little is known about the flying ability of the psy-

llids, and it is not known where most of them hibernate. When adult psyllids were disturbed while they were feeding, they jumped away powerfully and then flew back. They are slow fliers and do not give the impression of being able to fly great distances. They have been found on window screens about 150 feet away from the nearest hackberry tree in such numbers that it is most probable that they flew there deliberately rather than being blow accidentally. It should be noted, however, that the most widespread species, *P. celtidis-vesicula,* was the one which could most easily be spread by wind during the fall. The psyllids making woody galls, on the other hand, have little time in which to disperse, since the trees are in full leaf at the time they emerge from the galls, and they lay their eggs very shortly thereafter.

6. *Pachypsylla pallida* and *P. dubia* have not been found during these studies.

7. The "hackberry spiny gall' (original common name) presumably caused by *Cecidomyia spiniformis* was observed to be abundant on some hackberry trees in the state. These small conical, pointed galls tend to occur in groups on the underside of the leaves. No observations worthy of record have been made on this gall.

Parasites of Hackberry Gall Psyllids

In Idaho, Jensen (1946) reared three genera of Chalcidoid parasites from a group of petiole galls and nipple galls kept indoors during the winter. He listed *Callimome* sp., *Eurytoma* sp., and *Psyllaephagus* sp. near *pachypsyllae* but he did not know which parasites came from which galls.

Two species of parasites have been found to infest the bud gall pysllid. Waterston (1925) described *Psyllaephagus pachypsyllae* in Maryland; Walton (1944) found that in New York City 31.6 percent of the nymphs were destroyed by this parasite. Another wasp affecting this species is *Callomome scalaris,* listed by Huber in 1927.

Nymphs of *P. celtidis-gemma* and *P. venusta* in Manhattan, Kansas are parasitized by *Psyllaephagus pachypsyllae* (How.). *Torymus scalaris* (Huber) was reared from *P. celtidis-gemma* and an undetermined species of *Eurytoma* from *P. venusta* and 20 per cent of 67 galls of *P. celtidis-inteneris.* These wasps infested 18.4 per cent of the nymphs in 365 gall cells opened. Although this is appreciably less than Walton's finding of 31.6 per cent by *Psyllaephagus pachypsyllae* alone in New York City, it still shows that these parasites contribute substantially to the natural control of the bud gall psyllid.

Delayed leafing out in the spring: A possible undescribed type of psyllid damage

Some hackberry trees leaf out irregularly in the spring. Some will have only a few limbs in full leaf while the rest of the tree is bare. This is circumstantial evidence that psyllids kill the early crop of buds thereby causing the irregular leafing of some hackberry trees, but no report of this damage has been found in the literature.

Hackberry trees are hybrids and of the greatest variability in the characteristics of the foliage, roughness of the bark, time of leafing out, and attractiveness to psyllids. Some trees apparently have few galls on the leaves under normal conditions while others in the immediate vicinity have their foliage deformed and rendered unsightly by leaf galls.

It was noted that the leaves at the ends of the growing branches of younger, rapidly growing trees were generally devoid of all kinds of insect galls. These leaves apparently appeared after all the gall-making insects had died. The largest number of galls on the more susceptible trees occurred on the early leaves on main stems or branches.

Control of Hackberry Psyllids

Hackberry psyllids have generally not been the objects of control but in recent years occasional trees have been sprayed with generally unsatisfactory results. Raking and burning of the leaves in the fall in the hope of destroying the supposedly overwintering psyllids is of course wholly without value. Only the gall-makers of the bud gall (*P. gemma*) and the petiole gall (*P. venusta*) winter in the galls but these galls do not drop with the leaves.

The usual control suggested in the literature is to spray the tree with nicotine sulphate at the time the young leaves appear in order to destroy the psyllids which are on the tree. Apparently no one has published data on the effectiveness of this control.

Felt and Rankin stated that "spraying with a nicotine-soap-molasses solution, consisting of 1½ pints of nicotine, 3 pounds of soap and 9 pounds of molasses to 40 gallons of water, if properly timed will destroy practically all the insects and free the tree from infestation." Since nicotine was found in these tests to be unsatisfactory, it is reasonable to believe that the addition of molasses would not result in an improvement. Kotinsky (1921) stated "a contact insecticide like kerosene emulsion or water soluble oil (kerosene plus fish oil) at the time the young appear on the leaves in the spring and before the galls are entirely closed should give reasonable relief."

A pest control operator at Lincoln, Nebraska, has had good results with two pounds of wettable sulphur in 100 gallons of water. The proper timing of the spraying was found to be important.

Tests on Control of Hackberry Psyllids

It was thought that if the adult psyllids on the limbs and opening buds of hackberry trees could be destroyed, the leaves and twigs should be free of galls. Two small hackberry trees in the senior author's yard conveniently provided an experimental tree for the first control effort and a check tree. The experimental tree was first sprayed with DDT at the rate of 4½ tablespoonfuls of 50 per cent wettable DDT powder in one gallon of water. The spray was applied Saturday evening, May 3, 1947, by means of a two gallon compressed air sprayer and a step ladder was used to reach the tree top. The next morning May 4, no reduction in the numbers of the two species of psyllids on the tree was noted. The tree was again sprayed on Tuesday, May 6, with the same strength DDT but no favorable results were observed from this spraying. About an hour after each spraying, approximately two dozen psyllid adults of different sizes were collected from the buds and confined in small vials with some small hackberry leaves to determine the actual percent of killing at intervals. Following the spraying of DDT, all of the adults remained alive in the vials for a week when they died from natural causes.

On Sunday, May 12, 1947, a standard spray of "Black Leaf 40" and soap

was applied to the tree but no reduction in the adults on the tree was noted and those in the vials showed no effect from the spray.

On May 15th the tree was sprayed with "Vapatone Insect Spray R" (tetraethyl phosphates 9 per cent), 1 teaspoonful to 1 gallon of water, and the next morning no psyllid adults could be found on the tree. All of the psyllids collected an hour after spraying and confined in vials with hackberry leaves were dead the next morning. The buds had now opened and the leaves were expanded though still small. The psyllid adults began to fly to the tree from other hackberry trees in the vicinity so the tree was again sprayed with part of the same sprayerful of "Vapatone" on Monday evening, May 19. A marked reduction again occurred, but little or no residual effect was apparent because some adults were present on the foliage two days later, Wednesday, May 21. A few leaf galls were noted on May 19, though they were less numerous and not as large as those on the check tree.

The sprayed tree was almost wholly without nipple, bud, and petiole galls during the late spring and early summer but by August, galls began to appear on some of the smaller leaves. But the foliage on this tree was in excellent condition all season, and the number of leaf galls which developed was only a small fraction of the number on the unsprayed tree.

Because the small spray tests with TEPP appeared to give promising results, the city park spraying crew thoroughly sprayed 35 selected hackberry trees located along several streets in Manhattan, in the city park and on the college campus with TEPP on April 20, 1948, at the rate of ¾ pint of the fresh concentrate to 100 gallons of water. A high pressure power sprayer with two lines of hoses in the hands of experienced sprayer operators was used in these tests. Incidentally, one of the hosemen claimed to have become slightly ill from the TEPP spray mist.

Examination of the sprayed trees beginning six hours after spraying showed that few psyllids if any were killed. The results were classed as a complete failure.

A tree was then heavily sprayed with a hand sprayer using 1 teaspoonful of the TEPP concentrate (1 pint to 100 gallons) and a fair psyllid kill was obtained. The reduction was estimated at possibly 70 per cent.

A tree sprayed with "Vapatone" at the rate of 1 to 400 resulted in serious foliage damage to the tree. This was twice the recommended strength of spray. A good kill of psyllids resulted but two days later, live psyllids were found on the tree. There was little if any reduction in psyllid galls on the tree by mid-summer.

On May 3, 1949, several trees were sprayed with 12½ tablespoonfuls of 10 per cent gamma BHC emulsion to 1 gallon of water. After 30 minutes, no live psyllids could be found on the sprayed trees. Two live ones however were found on the sprayed tree after 12 hours. Other trees sprayed with this emulsion showed few live psyllids on the tree until 24 hours but they increased in numbers and leaf galls were plentiful later. So it was concluded that BHC emulsion was only a partial control.

The insecticidal spray tests in 1951 were designed specifically to control the blister gall psyllid. Six trees were sprayed with "Gamtox", "EPN-300", and "Black Leaf 40" combined with "Superla" summer oil. Each insecticide

was applied to a single branch on each of two trees when the trees began to leaf out. Blister gall psyllids were feeding and laying eggs on the young leaves at the time of application. Two months after the sprays were applied, the percentage of reduction in the number of blister galls was calculated by finding the average number of galls per leaf on the sprayed branch and comparing it with the average for the rest of the tree.

Results of the insecticidal spray tests showed that all three of the insecticides reduced the number of blister galls. "EPN-300" reduced them 80.5 per cent on one tree and 82.8 per cent on the other; "Gamtox", 76.7 per cent and 79.3 per cent; and "Black Leaf 40" with oil, 83.5 per cent and 57.7 per cent. The last figure was low because some blister galls had already formed at the time of spray application.

It was concluded that all of the materials used gave some control of the psyllids and a reduction in the number of the leaf galls. Complete freedom of psyllid galls was not obtained by any spray tests. It is believed that elimination of all psyllid galls would require from two to four sprayings, beginning with the swelling of the leaf buds and continuing until the tree is in full leaf.

Summary: Observations on hackberry psyllid galls at Manhattan over an eight year period showed that there were five species of psyllid galls present, four of which were common. The hackberry petiole gall, caused by *Pachypsylla venusta,* is the large polythalmous, gray, globular gall on the twigs. It was found to be frequent but was less disfiguring to the tree than the others. The psyllids wintered in the galls which persisted on the tree well into the next year. The psyllids emerged in the spring.

The smaller blister gall which is caused by *P. celtidis-vesicula* was the most common psyllid gall at Manhattan and the adults were the most numerous species on screens and in homes during the fall. This species emerged in the fall and wintered as adults probably in the crevices of bark and under leaves. The eggs were laid on the under side of the leaves but the nymphs crawled to the upper side of the leaves where their feeding resulted in a small blister-like, yellowish gall. Copulation was observed and described.

The hackberry nipple gall, caused by *P. celtidis-mamma,* is the large cone-shaped gall on the underside of the leaves. These are the most readily seen of the psyllid galls and detract most from the appearance of the tree. The psyllids emerged September to November at Manhattan and were a common annoyance in homes or on screens. Winter was passed in protected places and the adults were observed in April on the hackberry buds. The pale yellowish-green nymphs feed on the underside of the leaves and the galls form around them. The galls at first were pubescent.

The hackberry bud-gall, caused by *P. celtidis-gemma* attacks the bud which causes the bud to be swollen in appearance. Each bud attacked was destroyed by the psyllid. These galls were scarce at Manhattan. This is a first report for Kansas.

The hackberry twig galls, caused by *P. celtidis-inteneris* are swellings of the bark of twigs. This species was less common than the previous two species, but it is also much less easily seen. This gall has not been reported before for this state.

Two species of Hymenopterous parasites—*Psyllaephagus pachypsyllae* (How.) and *Torymus scalaris* (Huber) were reared from hackberry psyllid bud galls. They attacked 18.4 per cent of 365 galls examined.

The late and irregular leafing-out of some hackberry trees in May is believed to result from psyllid damage.

Test sprayings to destroy the adults on the buds and young leaves were made with DDT, nicotine sulphate, "Vapatone" (tetraethyl phosphate). BHC emulsion and EPN-300. DDT gave no perceptible control but all others killed many of the psyllids; but single sprayings did not keep the tree free of galls. Vapatone gave small scale promising results but failed in large scale tests. EPN-300 gave a reduction of 80 to 82 per cent of blister galls on the sprayed part of the two trees and nicotine sulphate with summer spray oil reductions of 57 to 83 per cent. Prevention of all psyllid galls would require spray applications at intervals over two or three months.

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EFFECTIVENESS OF SULFOXIDE-PYRETHRIN AGAINST HOUSE FLIES*

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Control of house flies has again become a major problem since the development of resistance to practically all of the newer insecticides. Recently much work has been devoted to the development of combinations of materials to prevent detoxification. Other work based on the synergistic action of one material on another has been done. At the same time it has been necessary to attempt to provide a fair degree of residual activity. The sulfoxide-pyrethrin[1] combination is of this type.

An opportunity to compare the effectiveness of the sulfoxide-pyrethrin formulation with several of the chlorinated hydrocarbons was presented when heavy fly populations were found in nearby farm buildings. Two hog houses, two beef cattle barns, one calf barn, and one dairy barn were used in the tests. Manure removal around the hog houses was poor and flies were breeding in large numbers. Sanitary practices in the beef cattle barns were better but not satisfactory. Good sanitation was in practice at the dairy barn. All buildings were nearly on an east-west line and only about one mile separated the farthest one on the west from the farthest one on the east.

Materials and Methods. The materials compared in the test were sulfoxide-pyrethrin wettable powder 2-20 (2 per cent pyrethrin and 20 per cent sulf-

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[1] Material supplied through the courtesy of S.B. Penick and Co., 50 Church St., New York 8, N. Y.
[2] Moorman's concentrate containing 30 per cent DDT and methoxychlor combined.

oxide); sulfoxide-pyrethrin emulsion 1-10; DDT-methoxychlor emulsion[2]; DDT 50 per cent wettable powder; methoxychlor 50 per cent wettable powder and lindane 25 per cent wettable powder. The sulfoxide-pyrethrin formulations were applied in the hog houses. DDT and the DDT-methoxychlor emulsion were applied in the beef cattle barns. Methoxychlor was used in the calf pens. Lindane was used in the dairy barn. All materials were sprayed on the ceilings, walls, and on posts or pen sidings. Spraying was done with a 15 gallon power sprayer delivering a fine mist to just wet the surface.

A pre-treatment count was taken in all buildings just before application by recording the number of flies collected in ten consecutive sweeps of a net. Result counts were taken in the same manner at one and three days, one week, two weeks, three weeks, and four weeks after treatment. Counts were discontinued in some barns at the end of one, two, and three weeks. Results are given in Table 1.

TABLE 1. *Control of Flies in Barns*

		Pretreatment	Per Cent Control at					
Material	Rate	Count	1 day	3 days	1 wk.	2 wks.	3 wks.	4 wks.
Sulfoxide Pyrethrin WP 2-20	7 lbs. in 15 gals.	428	94.2	96.3	83.0	91.0	0	-
Sulfoxide-Pyrethin EM 1-10	3 pints in 15 gals.	177	68.0	9.0	0	31.0	0	-
DDT-Methoxychlor EM	1 gal. in 7 gals.	106	15.0	88.0	0	77.0	43.0	0
DDT WP	12 lbs. 50% in 100 gals.	91	7.0	0	7.0	7.0	-	-
Methoxychlor WP	12 lbs. 50% in 100 gals.	70	0	62.0	0	0	-	-
Lindane WP	10 lbs. 25% in 100 gals.	70	53.0	76.0	0	-	-	-

A result count larger than the pretreatment count is indicated by zero control in table 1. Below is a listing of the per cent increase over the pretreatment count for each treatment.

Sulfoxide-pyrethrin WP—15 per cent at 3 weeks.

Sulfoxide-pyrethrin EM—31 and 134 per cent at one and 3 weeks respectively.

DDT-methoxychlor EM—8 and 51 per cent at one and 4 weeks respectively.

DDT WP—7 percent at 3 days.

Methoxychlor WP—33, 140 and 220 per cent at one day, one week and 2 weeks respectively.

Lindane WP—90 per cent at one week.

Upon termination of control in the dairy barn with lindane, the sulfoxide-pyrethrin wettable powders were applied at the same rate as used in the hog house. Following in Table 2 are the results taken from this application.

TABLE 2. *Results from Sulfoxide-Pyrethrin Treatment in Dairy Barn.*

Material	Pretreatment Count	Per Cent Control at 1 day	3 days	1 wk.	2 wks.	3 wks.
Sulfoxide 7 lbs. Pyrethrin in 15 gals. WP 2-20	135	65.0	53.0	53.0	86.0	0

Conclusion:

At the end of two weeks the sulfoxide-pyrethrin wettable powders had given an average of 91 per cent control calculated on the basis of the pretreatment count. At the end of three weeks there was an increase of 15 per cent over the pretreatment count. This period of control was one week longer and of a much higher degree than that provided by lindane in the dairy barn. Population pressure was much less in the dairy barn than in the hog houses. The 1-10 emulsion also gave better results and a longer period of control than did lindane but did not equal the wettable powders of sulfoxide-pyrethrin. DDT-methoxychlor lasted longer than any other treatment but did not provide the high degree of control obtained with the sulfoxide-pyrethrin wettable powders. Neither DDT nor methoxychlor alone were effective. Both pyrethrin formulations showed extremely rapid knockdown.

Summary. Sulfoxide-pyrethrin wettable powders gave better house fly control in barns than did sulfoxide-pyrethrin emulsion, DDT, methoxychlor, a combination of DDT and methoxychlor, or lindane. Neither DDT nor methoxychlor alone were effective.

EFFECT OF FOOD ON THE LIFE HISTORY OF THE FLOUR BEETLE, *TRIBOLIUM CASTANEUM* HERBST

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Introduction

Tribolium castaneum Herbst is a well known pest of stored grains and other products in India and throughout the world (Pruthi and Singh, 1945). The biology of *T. confusum* Jacq. Duval and *T. ferrugineum* Fabricius, which are also cosmopolitan in distribution, has been worked out by Good (1933). Fletcher (1914) and Pruthi and Singh (1945) have touched upon the life history of *T. castaneum* but the details remain wanting. Blair (1930) and Good (1933) dealt with its distribution. The species *castaneum* is mainly tropical in distribution and is dominant if not endemic in India; it cannot withstand cold climate (Freeman, 1946, Munro, 1940).

Since this species infests a number of foodstuffs and it is not known how far the different media affect its life cycle, the authors have endeavored to give a detailed account of its life history in relation to different foodstuffs such as wholewheat flour (*Atta*), refined or white wheat flour (*Maida*), barley, and arrowroot flour in order to find out the effect of the varied foods on its life history. The effect of light on the pupal development is also mentioned.

Material and Method

This pest was raised in the laboratory from collections of specimens made from store houses and granaries in Calcutta. The life history from egg stage to maturity was traced by maintaining the specimens in glass vials which contained respectively arrowroot, barley, wholewheat and refined wheat flour kept under room temperature and humidity of the laboratory. A daily record of humidity and temperature was kept. All rearings were done simultaneously, so that conditions of temperature and humidity were the same for all groups of larvae. A single freshly laid egg was put in each vial and the time of emergence of the larva was noted. The larvae were etherized for measurement immediately after hatching and after each moult. They were divided

TABLE I—Number of eggs laid in ten days based upon four females per food material.

Foodstuff	Eggs laid per female in 10 days av. (max., min.)	Daily output per female av. (max.)
Arrowroot	2 (4, 1)	0.2 (2)
Barley	20.8 (25, 18)	1.9 (5)
Whole wheat flour	35 (47, 25)	3.5 (10)
Refined wheat flour	28.8 (35, 24)	2.7(7)

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Table II—Number of instars and duration of larval life when reared on different foodstuffs; Room temperature: 78° F.-88° F. Humidity; 66-92 (relative).

Food		Instars									Average number of instars	Entire larval period
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th		
Arrowroot	No. of larvae	12	7	5	0							
	Range of days	3-17	5-21	1-48	died							
	Av. no. of days	7.5	9.8	25.2								
Barley	No. of larvae	10	10	10	10	10	10	8	2	1		10
	Range of days	2-5	4-11	4-7	4-6	4-8	3-10	3-15	11-6	5	7.1	33-56
	Av. no. of days	4.1	6.4	5.2	5.1	5.9	5.5	7.8	13.5	5.0		41.7
Wholewheat flour	No. of larvae	7	7	7	7	7	6	5				7
	Range of days	2-4	1-4	2-4	3-5	4-6	3-6	5-11			6.6	21-35
	Av. no. of days	2.8	2.8	3.2	3.8	4.5	4.5	7.2				26.4
Refined wheat flour	No. of larvae	9	9	9	9	6	2					9
	Range of days	3-5	3-7	4-11	4-22	6-23	11-13				4.9	32-45
	Av. no. of days	4.1	4.4	7.5	11.1	11.6	12					37.7

into four groups, the first was reared on arrowroot, the second on barley, third on wholewheat and the fourth on refined wheat flour. The adults thus raised were also fed with the same foodstuffs so as to note the effect of these different foods on egg laying. It may be remarked that Munro (1940) rightly points out that these beetles do not survive if offered only whole grains of wheat. We have therefore based our expriments on flours.

Fertility and Viability

Table I shows the number of eggs laid within a period of ten days by four mature females obtained from storehouses. Four individuals were placed in each food material From this table it is seen that when the insects are fed on wholewheat flour the average daily output is relatively high, so that the maximum number of eggs deposited in a single day may be as high as ten. If the insects are fed on arrowroot the average number of eggs is much less.

Of 130 eggs observed, 39 failed to hatch, giving a viability of about 70%. Of the 91 that hatched, 3 (3.3%) hatched the first day after laying, 6 (6.16%) the second day, 40 (44%) the third day, 37 (40.7%) the fourth day, 3 (3.3%) the fifth day, and 2 (2.2%) the sixth day. A large number of deaths was caused by infestations of mites.

Number and Length of Larval Stadia

Table II shows the effect of foodstuffs on the larval life. The successive columns show the numbers of larvae that were found in each stage. The gradual decrease in numbers occurs as the larvae passed into the pupal stage except that on arrowroot they died instead of pupating. The entire larval period from hatching to pupation is shown in the last column. The maximum number of instars (9) occurred when the larvae were reared on barley. These individuals also had the longest average larval life. When fed on wheat flours the number of instars is reduced to maxima of 6 and 7 and the duration of the total larval life is also reduced. It is noteworthy that on arrowroot (obviously a deficient diet) larvae do not progress beyond the third instar and the duration of the stadia is prolonged to a maximum of 48 days.

From tables II and III the following facts may be deduced: First, each stadium is larger than the preceeding one. Secondly, the number of instars is controlled in part by foodstuff (other factors being maintained similar). Thirdly, the number of instars varies slightly even with the same food though other factors such as temperature and humidity remain the same. The rate of growth as measured by linear increase in length after successive moults as shown in table III is influenced by foodstuffs under similar conditions of temperature, moisture and other factors. Further, as seen from the lines marked "increase in length" on table III, the growth at each instar is irregular. Occasionally, in some individuals, increase in length at the second instar is followed by a reduction in length at the next stadium and another rise at a later stadium.

Pupal Period

The pupal period of each of 43 pupae kept in darkness was five days, emergence occurring on the sixth day, except that one pupa (out of 13 whose larvae had been fed on barley) emerged on the fifth day.

Table III—Lengths of the specimens in mm. at different stadia when reared on different foodstuffs.

Foodstuff		Instars								
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Arrowroot	No. of larvae	12	7	5	0					
	Range	1.00-1.80	1.50-2.00	2.00-2.20						
	Av. length	1.40	1.70	2.10						
	Increase in length		0.31	0.49						
Barley	No. of larvae	10	10	10	10	10	10	8	2	1
	Range	1.00-1.25	1.50-2.00	1.75-2.00	2.00-3.00	2.75-4.50	3.50-5.00	4.00-5.25	4.50-5.25	5.25
	Av. length	1.06	1.25	1.97	2.40	3.25	3.97	4.84	4.84	5.25
	Increase in length		0.49	0.42	0.43	0.85	0.72	0.87	0	
Wholewheat flour	No. of larvae	7	7	7	7	7	6	5		
	Range	1.00-1.25	1.50-2.00	1.25-2.25	2.15-3.75	2.75-5.00	3.25-5.00	4.00-5.25		
	Av. length	1.12	1.38	2.12	2.78	3.39	4.20	4.80		
	Increase in length		0.26	0.74	0.66	0.61	0.81	0.60		
Refined wheat flour	No. of larvae	9	9	9	9	6	2			
	Range	1.00-1.25	1.50-2.00	1.75-2.25	2.25-4.00	2.25-4.00	3.50-3.95			
	Av. length	1.11	1.58	2.02	3.02	3.50	3.72			
	Increase in length		0.47	0.44	1.00	0.48	0.22			

If pupation is allowed to take place under the light and heat of an electric lamp, the pupal period is shorteneded so that among 26 pupae so treated 7 emerged on the fourth day and 19 on the fifth.

Pupae exposed to strong sunlight were killed.

Chemical Contents of Food

Table IV shows the chemical contents and nutritive value of the four different foodstuffs used for rearing the insects. According to the table whole wheat flour is richer in vitamin B_1 than any of the other foods. It is important to notice the absence of vitamin B_1 in arrowroot flour. It is also evident from this table that arrowroot contains much less protein than the other foods and that the percentage of carbohydrate in arrowroot is higher than in the other foods. There is no marked variation in other chemical contents in these four different foodstuffs used for the experiments.

Good (1933) reports that the maximum number of eggs laid by a female of *T. ferrugineum* in a day is 13 though the average output comes to 2 or 3, while Brindley (1930) gives the maximum number as 18. In the species *castaneum* observed by us the maximum daily output of eggs does not exceed 10. This number is obtained if the specimens are fed on wholewheat flour which relatively speaking contains the most vitamin B_1 and protein and goes down to 1 if feeding is on arrowroot which is very poor on Vitamin B_1 and protein. It is interesting that the number of eggs laid is influenced by foodstuffs. Egg laying continues for months and in 10 days the female if fed on wholewheat flour may deposit as many as 47 eggs while in the same period, if fed on arrowroot, the maximum number of eggs deposited was 4 (Table 1).

Pruthi and Singh (1945) record that the incubation period of eggs in this species varies from 5 to 12 days depending upon temperature in the Indian climate. We find that at our laboratory room temperature during the month of August all the eggs hatch within 6 days after deposition and the majority on the third and fourth days.

Chapman (1918) and Brinely (1930) observed that the larvae of *T. confusum* undergo six instars before becoming pupae, but Good (1933) contradicted this view and opined that there is no fixed number of larval moults. According to his observations on the same species the number of instars ranges from 6 to 11 or more and is normally 7 or 8 instead of 6 as mentioned by previous workers. In the present study with the species *castaneum* the writers have found that the later view is more correct, differences in feeding accounting for part of the fluctuation. The number of instars varies from 6 to 9.

It should be pointed out that the number of instars varies even when fed on the same foodstuff. This fluctuation is most noticeable among larvae fed on barley where we find prolonged larval life with growth relatively slow. The total larval period varies from 21 to 56 days (Table II). Pruthi and Singh (1945) opine that the period varies from 27 to 90 days according to food available and prevailing temperature. We find that if the larvae are fed on wholewheat flour the period varies between 21 and 35 days and when fed on barley this is between 33 and 56 days. The largest number of deaths occurred when the larvae were fed on arrowroot and in these cases none got be-

Table IV—Chemical contents of different foods used.

Foodstuff	Moisture %	Protein %	Fat (Ether extractives) %	Mineral matter %	Carbohydrate %	Calcium (Ca) %	Phosphorous (P) %	Iron (Fe) mgs. %	Calorific value per 100 gms.	Vitamin B_1 (Micro-grammes per 100 gms.	Nicotinic Acid mgs. per 100 gms.	Riboflavin μ gms. per 100 gms.
Arrowroot flour	16.5	0.2	0.1	0.1	83.1	0.01	0.02	1.0	334	.....	...	.....
Barley	12.5	11.5	1.3	1.5	69.3	0.03	0.23	3.7	335	450	4.7	.....
Whole wheat flour	12.2	12.1	1.7	1.8	72.2	0.04	0.32	7.3	353	500	5.0	120
Refined wheat flour	13.3	11.0	0.9	0.4	74.1	0.02	0.09	1.0	349	120	...	.....

yond the third instar. No deaths, except those due to mechanical injury, occurred among larvae fed on other foods.

According to Fletcher (1914) the pupal stage lasts for 4 or 5 days while Pruthi and Singh (1945) report that it lasts for 6 to 9 days. The writers find a pupal period of 5 days. It is important to note that the nature of the larval food has no significant effect on the duration of the pupal period.

Good (1933) observed that *T. ferrugineum* kept in continuous light at room temperature had a pupal period of 5 to 14 days with an average of 8.5 days but we note that in *T. castaneum* the pupal stage lasts for 3 to 4 days if kept under continuous light. In the majority of cases the imago is formed on the fifth day. This shows that light or the accompanying heat accelerates the pupal development.

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